Use of NRL P-3 and ELDORA in TPARC/TCS-08

David J. Raymond
Physics Department
New Mexico Tech
801 Leroy Place
Socorro, NM 87801

Award Number: N000140810241

LONG-TERM GOALS

The long-term goals of this project are to understand better the mechanisms operative in tropical cyclogenesis and to transfer this knowledge to large-scale models in order to improve forecasts of tropical storm formation. Since convection constitutes the biggest uncertainty in this process, our focus is to understand how convection affects and is affected by cyclone-scale flows.

OBJECTIVES

Our objectives in this segment of the program were to obtain observations of the vertical transports of mass and momentum by convection and to see how these transfers varied with convective environment. The important environmental factors are thought to be the temperature and humidity profiles, the wind profile, and the surface fluxes of heat, moisture, and momentum.

APPROACH

The Eldora Doppler radar on board the NRL P-3 aircraft was used to determine the flow patterns and reflectivity structure of moist convection in a wide variety of convective environments while dropsondes from from the P-3 itself, the Air Force Reserve C-130 aircraft, and on occasion the Taiwanese Dotstar aircraft and the German Falcon were used to define the convective environment. The Doppler lidar on board the NRL P-3 was used to obtain wind profiles both above and below the aircraft as well.

In order to be able to incorporate the results from a diverse set of sensors into a single product on which various analyses can be made, we have been developing a three-dimensional variational analysis (3-D Var) scheme. Much of the work of this type has been directed to initializing numerical models, which is appropriate for improving model forecasts. Our work differs in that we wish to develop as comprehensive a picture of an observed system as possible without introducing model biases and preconceptions. Thus, we plan to impose only the simplest possible constraints beyond the data itself, e. g., mass continuity, small vertical velocity in convection-free regions, etc. Model results are not used to provide an initial guess to the analysis.

David Raymond (the PI), research physicist Carlos López, and graduate student Jorge Cisneros (supported separately under an NSF grant) are all working on the radar data analysis.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2008	**Annual**	**00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE **Use Of NRL P-3 TPARC/TCS-08**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **New Mexico Tech,Physics Department,801 Leroy Place,Socorro,NM,87801**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT
The long-term goals of this project are to understand better the mechanisms operative in topical cyclogenesis and to transfer this knowledge to large-scale models in order to improve forecasts of tropical storm formation. Since convection constitutes the biggest uncertainity in this process, our focus is to understand how convection affects and is affected by cyclone-scale flows.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Carlos López is developing the new 3-D Var scheme. Raymond has been dealing with the dropsonde data. Raymond, López, and Cisneros (under NSF support) spent the entire field period (minus the extension) in Guam. Undergraduate students Michael Herman, Anna Nuckolls, and Melissa Williams supported the field effort from Socorro by putting various products derived from NCEP's GFS model and the associated final analysis (FNL) on our web page where we could access it. These students were also supported by NSF.

WORK COMPLETED

The NRL P-3 aircraft flew 21 research missions in which useful data were obtained along with two instrument calibration missions. Most, but not all missions were accompanied by dropsondes from at least one of the other three aircraft, primarily the C-130. In cases in which the areal coverage of convection was not too great, the C-130 was able to fly at roughly 10 km elevation, which resulted in an unexpectedly deep layer documented by dropsondes from this aircraft. If convection became too extensive, the C-130 descended to 3 km. The P-3 was generally flown at either 2.3 km or 3.7 km, the latter altitude being favored in the absence of the C-130 in order to drop sondes from a higher elevation.

The number of P-3 flights into different categories of systems can be categorized as follows:

- Pre-tropical-storm: 5.
- Non-developing system: 6.
- Tropical storm: 3.
- Typhoon in tropics: 3.
- Typhoon in extratropical transition: 4.
- Calibration flights: 2.

We thus have an excellent selection of flights into a wide variety of convective environments.

Aside from some initial teething problems, the refurbished Eldora radar worked well through the majority of the project, producing very high quality radar data. For the most part, excellent dropsonde data were obtained as well, though a few flights suffered from high sonde failure rates due to a problem with a new GPS chip used by Vaisala. This problem went away after NCAR determined how to reprogram the firmware in these chips. The Doppler lidar appeared to work well on most flights, though it would occasionally hang up in a particular pointing direction, which made it unusable for the balance of the flight.

Progress has been made on implementing the 3-D Var scheme, though currently the results are limited to radar data alone. (This is the most difficult component to implement.) In the course of this work we discovered that including differential constraints such as mass continuity as a weak constraint (i. e., incorporated by including a term in the cost function) causes the most commonly used 3-D Var schemes to converge unacceptably slowly. Investigation revealed that a multi-grid version of the analysis scheme had the potential to speed

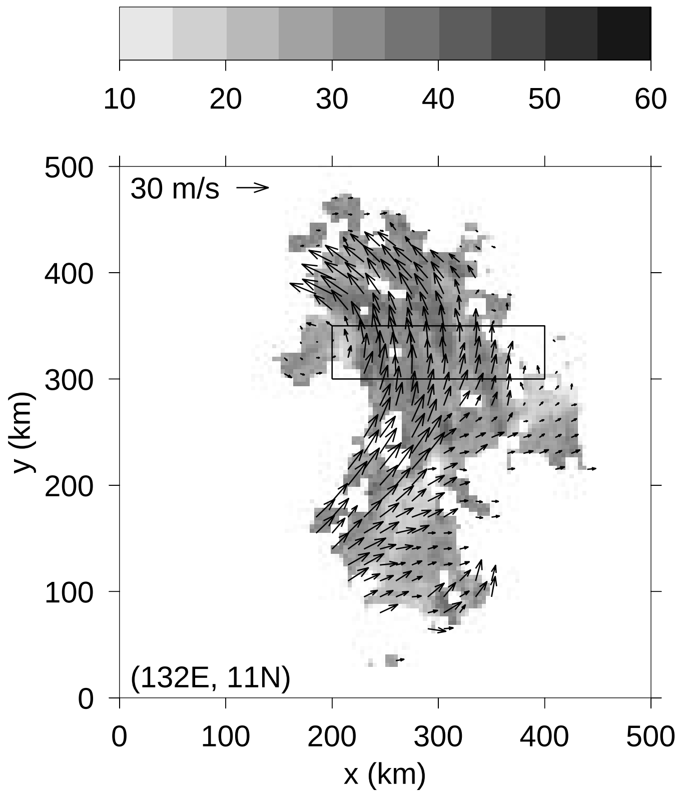

Figure 1: Eldora radar winds (vectors) and reflectivity (gray scale, dBz) at 1 km elevation relative to storm motion on tropical storm Jangmi near 00 UTC on 25 September 2008. The rectangle represents a region selected for further analysis. The SW corner of the graphic was located at 132° E, 11° N.

up convergence to an acceptable level. This scheme has been coded and is being tested at this point.

RESULTS

As less than one month has passed since the end of the field program, we are far from having definitive results to report. However, we have performed some preliminary Doppler radar analyses of one case, that of Jangmi, when it was rapidly intensifying from a strong tropical storm into a typhoon. We were able to document the rainband that was developing into the eyewall of this storm.

Figure 1 shows the horizontal winds and reflectivity at 1 km elevation in the rainband in the reference frame of Jangmi, which was moving to the WNW at about 6 m s^{-1}. Note that the rainband is wrapping around a central circulation with maximum winds of order 30 m s^{-1}. We hypothesize that this circulation represents the nascent eye, and that the rainband is becoming the eyewall.

Figure 2 shows an east-west or cross-rainband section, showing the cross-band circulation and the along-band winds. A descending jet enters the band from the east, reaching the surface near the west side of the band, and then ascending abruptly. This likely represents the developing in-up-out circulation of the nascent eyewall.

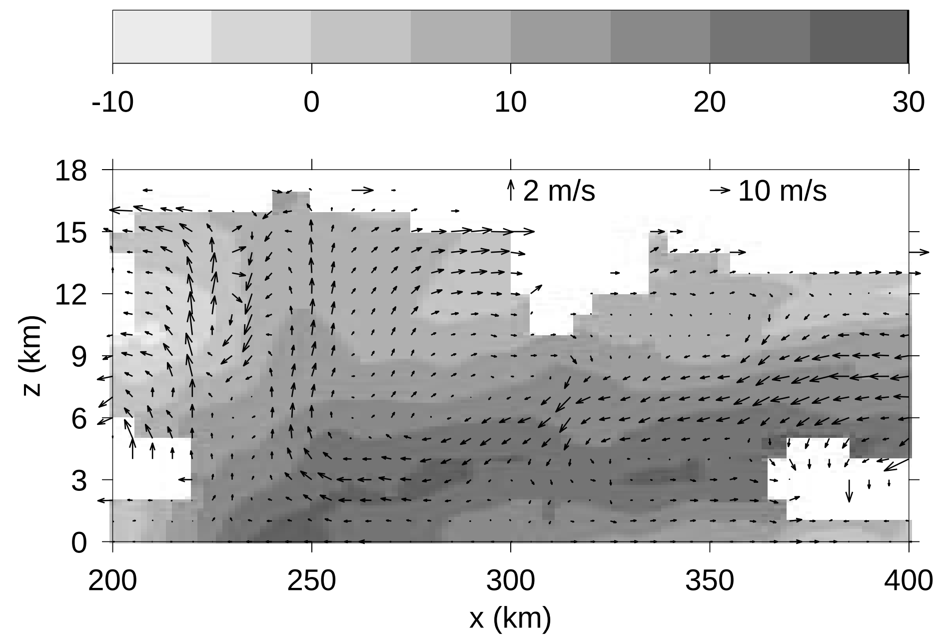

Figure 2: East-west cross-section averaged over $300 \leq y \leq 350$ km (see figure 1) showing the cross-band and vertical winds (arrows) and the along-band wind (gray scale). Along-band winds exceed 25 m s^{-1} at the surface near $x = 240$ km.

These results represent only a tiny fraction of what we have obtained in this project. We look forward to further results and their interpretation in the coming years.

IMPACT/APPLICATIONS

As we are just beginning to dig into the results of this experiment, it is too early to speculate on its impacts beyond those which were indicated in the initial proposal. However, given the high quality of the data obtained on an interesting set of cases, I am sure that the ultimate yield from this project will be high.

RELATED PROJECTS

This project is related to work being pursued under a grant from the National Science Foundation entitled "A Rational Approach to Cumulus Parameterization in Large-Scale Models". In this project the feasibility of using a cloud-resolving numerical model in "weak temperature gradient mode" to test cumulus parameterizations is being explored. Data from the TCS-08 field program will be used to test the cloud-resolving model.